US009317893B2

(12) **United States Patent**
Chen

(10) **Patent No.: US 9,317,893 B2**
(45) **Date of Patent: Apr. 19, 2016**

(54) **METHODS AND SYSTEMS FOR CORRECTING A DOCUMENT IMAGE**

(71) Applicant: **Sharp Laboratories of America, Inc.**, Camas, WA (US)

(72) Inventor: **Lawrence Shao-hsien Chen**, Vancouver, WA (US)

(73) Assignee: **Sharp Laboratories of America, Inc.**, Camas, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 277 days.

(21) Appl. No.: **13/851,056**

(22) Filed: **Mar. 26, 2013**

(65) **Prior Publication Data**

US 2014/0292802 A1 Oct. 2, 2014

(51) **Int. Cl.**

G06T 3/00	(2006.01)
G06K 9/34	(2006.01)
G06K 9/36	(2006.01)

(52) **U.S. Cl.**

CPC ***G06T 3/0031*** (2013.01); *G06K 9/34* (2013.01); *G06K 2009/363* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,885,479	B1	4/2005	Pilu	
6,940,664	B1	9/2005	Pilu	
7,330,604	B2	2/2008	Wu et al.	
7,576,738	B2	8/2009	Litke et al.	
7,586,655	B1	9/2009	Uhlik et al.	
7,593,595	B2	9/2009	Heaney, Jr. et al.	
7,623,274	B1	11/2009	Lefevere	
7,660,458	B1	2/2010	Saric	
7,697,776	B2	4/2010	Wu et al.	
7,835,589	B2	11/2010	Heaney, Jr. et al.	
7,907,171	B2 *	3/2011	Miyamoto et al.	348/207.1
7,974,463	B2	7/2011	Saric	
8,072,654	B2	12/2011	Lefevere	
2004/0022451	A1 *	2/2004	Fujimoto et al.	382/275
2004/0258327	A1	12/2004	Cheatle et al.	
2006/0267978	A1	11/2006	Litke et al.	
2007/0247458	A1 *	10/2007	Surazhsky	345/423
2008/0285878	A1	11/2008	Morichika et al.	
2010/0073735	A1	3/2010	Hunt et al.	
2010/0239165	A1	9/2010	Wu et al.	
2012/0206778	A1 *	8/2012	Shirai et al.	358/474
2012/0250112	A1	10/2012	Ogawa et al.	
2013/0268847	A1 *	10/2013	Kim et al.	715/251
2014/0098142	A1 *	4/2014	Lee et al.	345/676

FOREIGN PATENT DOCUMENTS

JP	2005045723	A	2/2005
JP	2012-170049	A	9/2012

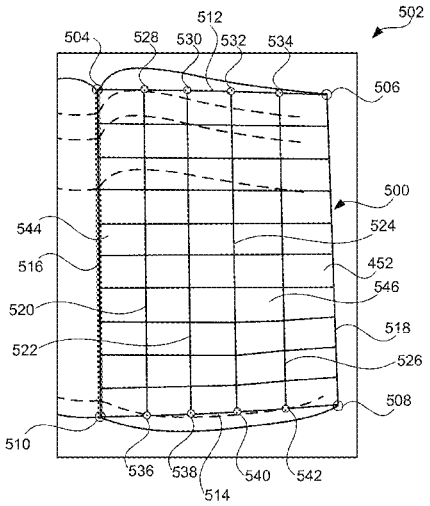
* cited by examiner

Primary Examiner — Phi Hoang
Assistant Examiner — Diane Wills
(74) *Attorney, Agent, or Firm* — Kristine Elizabeth Matthews; David C. Ripma

(57) **ABSTRACT**

Aspects of the present invention relate to methods and systems for fitting a mesh to an image of a document page and correcting a distortion in the image of the document page using the mesh. A rectangular-form mesh may be overlaid on a displayed document image. Corner points in the rectangular-form mesh may be moved to coincide with corner points of a document page in the displayed document image, and a corner-aligned mesh may be overlaid on the displayed document image. A cubic Bezier curve may be fit to the top edge of the document page, a cubic Bezier curve may be fit to the bottom edge of the document page and an edge-aligned mesh may be overlaid on the displayed image. An inverse projective transformation may be applied to the patches of the mesh to correct the distortion in the image of the document page.

20 Claims, 6 Drawing Sheets



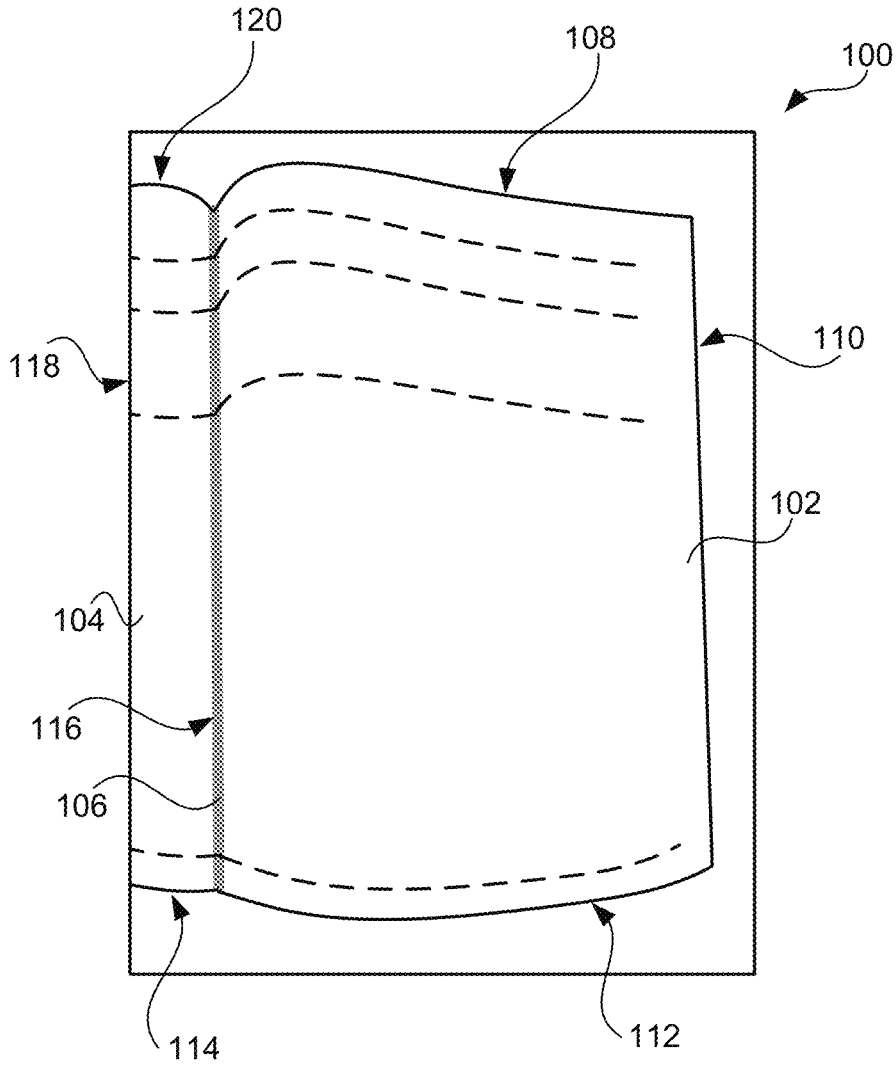

120
108
100
118
110
102
104
116
106
114
112

FIG. 1

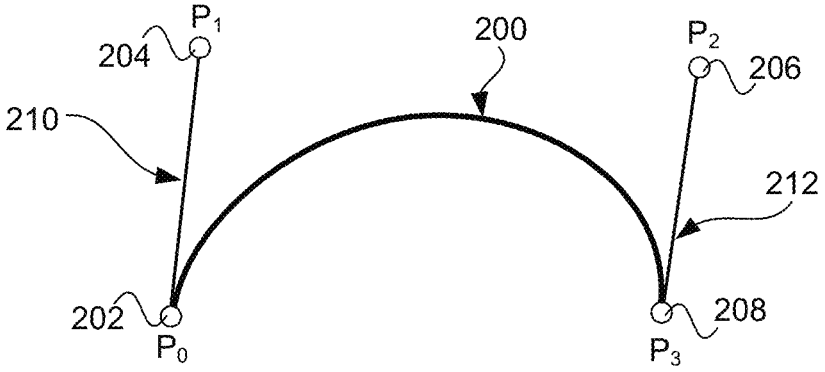

P1
204
200
P2
206
210
212
202
P0
208
P3

FIG. 2

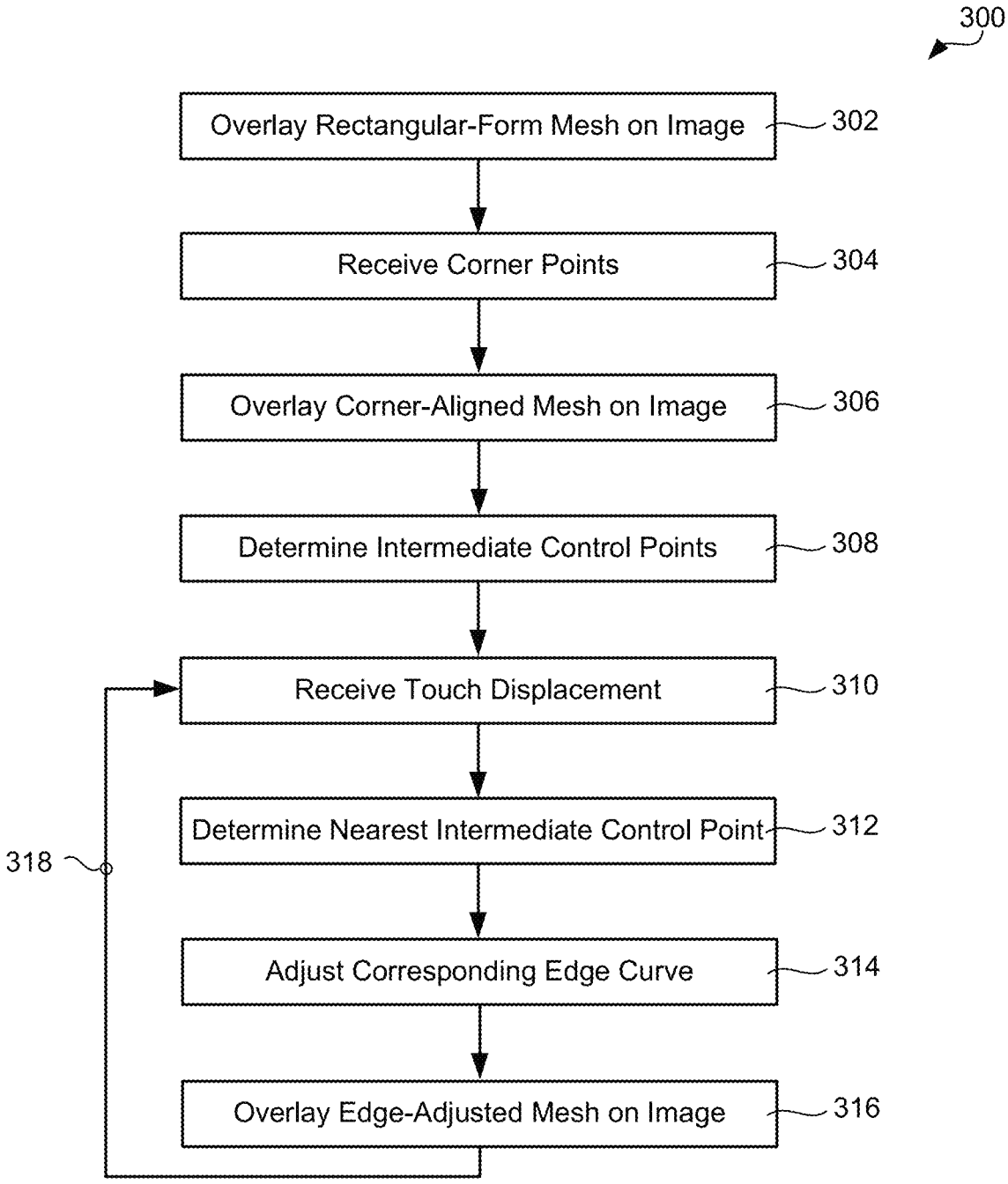

300
Overlay Rectangular-Form Mesh on Image
302
Receive Corner Points
304
Overlay Corner-Aligned Mesh on Image
306
Determine Intermediate Control Points
308
Receive Touch Displacement
310
Determine Nearest Intermediate Control Point
312
318
Adjust Corresponding Edge Curve
314
Overlay Edge-Adjusted Mesh on Image
316

FIG. 3

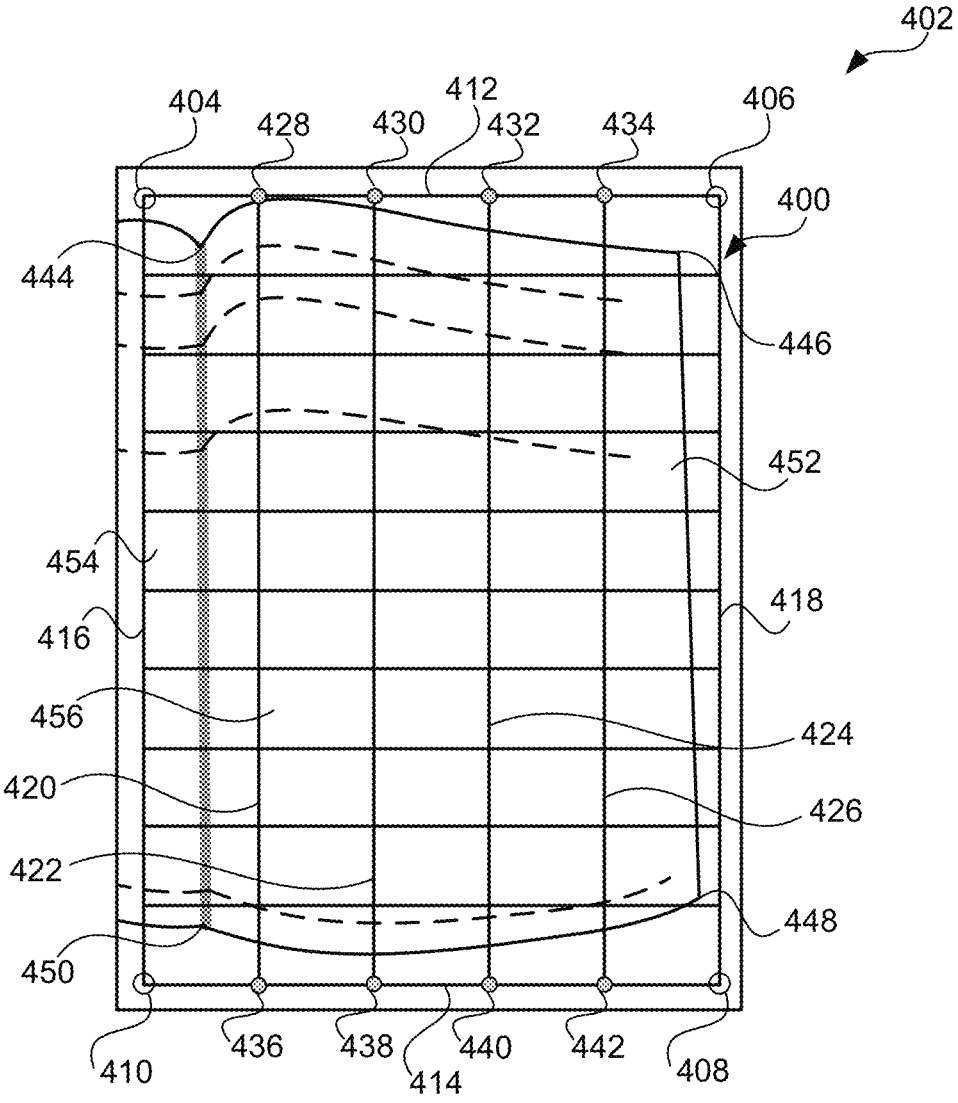

402
404
412
406
428
430
432
434
400
444
446
452
454
418
416
456
424
420
426
422
448
450
410
436
438
440
442
408
414

FIG. 4

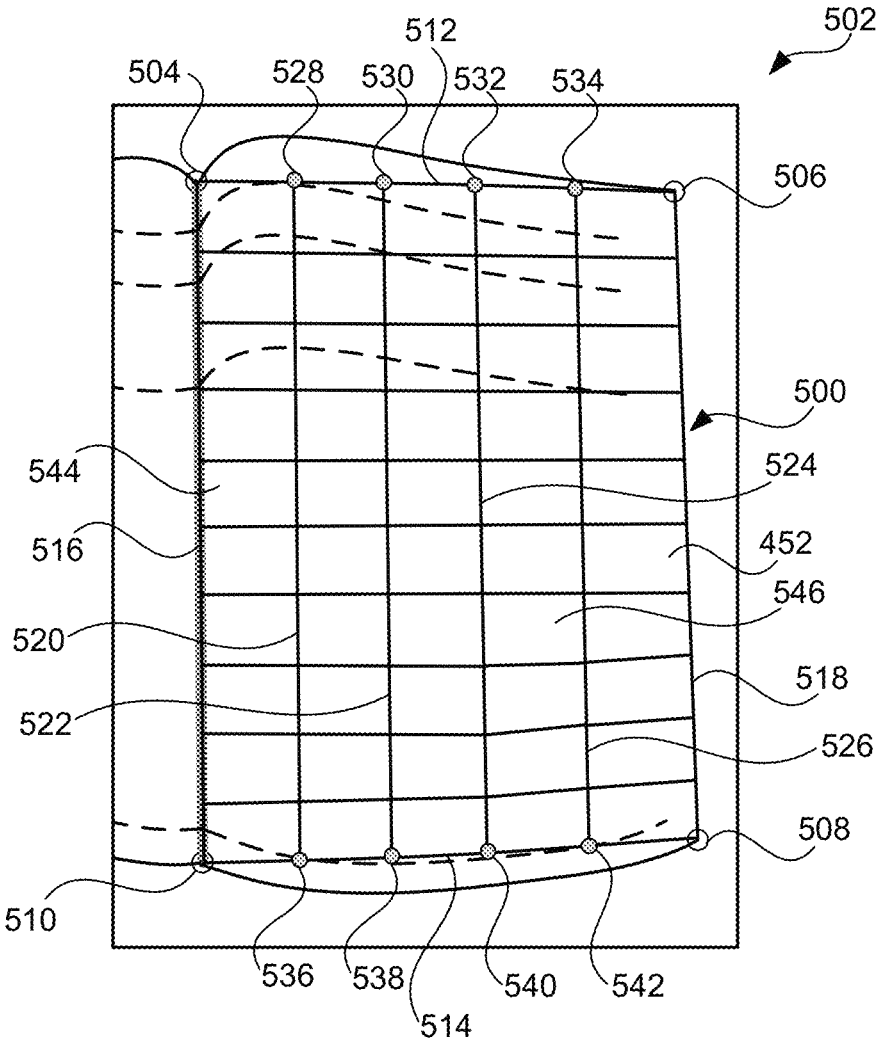

502
512
504
528
530
532
534
506
500
544
524
516
452
546
520
518
522
526
508
510
536
538
540
542
514

FIG. 5

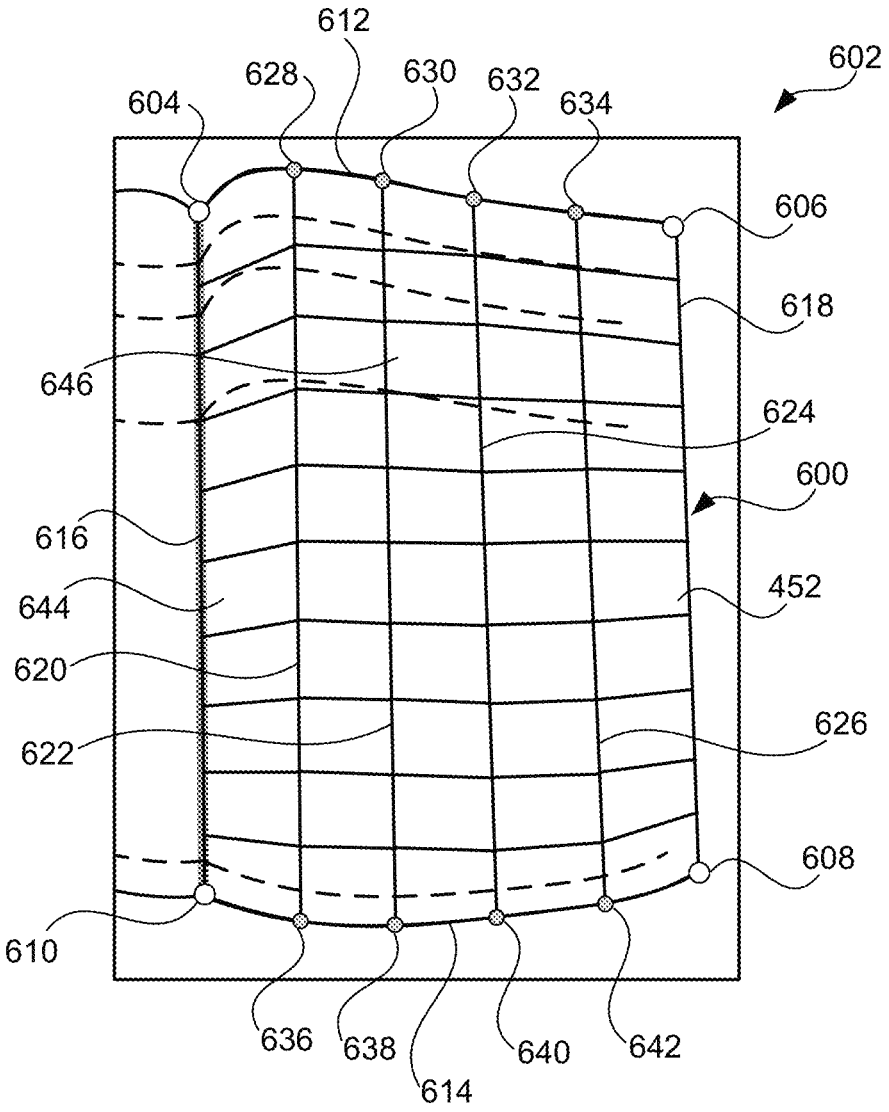

612
628
630
632
634
602
604
606
618
646
624
600
616
452
644
620
626
622
608
610
636
638
640
642
614

FIG. 6

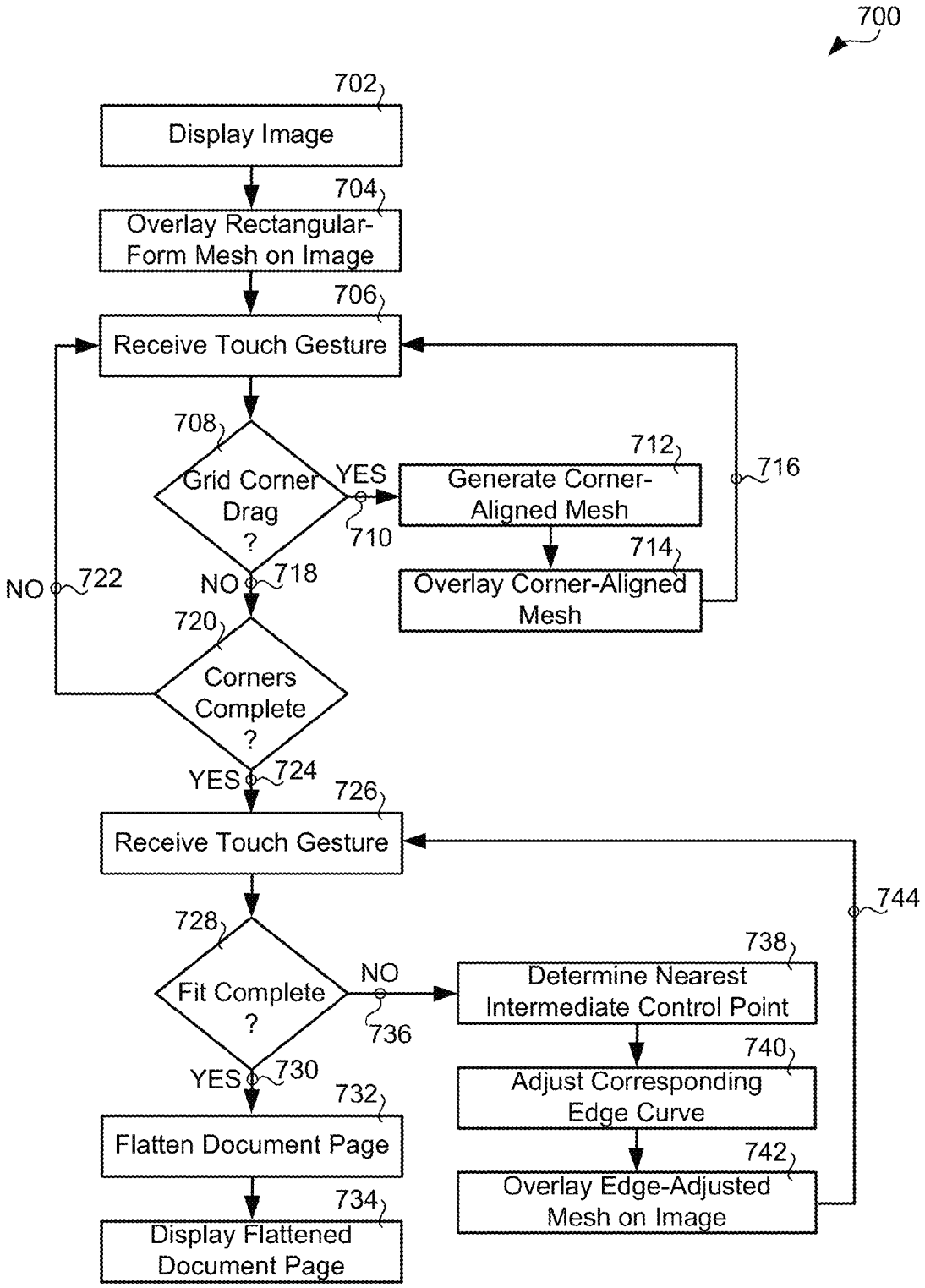

700
702
Display Image
704
Overlay Rectangular-Form Mesh on Image
706
Receive Touch Gesture
708
Grid Corner Drag ?
YES
710
712
Generate Corner-Aligned Mesh
714
Overlay Corner-Aligned Mesh
716
NO
718
722
720
Corners Complete ?
YES
724
726
Receive Touch Gesture
728
Fit Complete ?
NO
736
738
Determine Nearest Intermediate Control Point
740
Adjust Corresponding Edge Curve
742
Overlay Edge-Adjusted Mesh on Image
744
YES
730
732
Flatten Document Page
734
Display Flattened Document Page

FIG. 7

METHODS AND SYSTEMS FOR CORRECTING A DOCUMENT IMAGE

FIELD OF THE INVENTION

Embodiments of the present invention relate generally to methods and systems for image processing and, in particular, to methods and systems for correcting distortion in an image of a page in a bound publication.

BACKGROUND

Capturing a non-distorted digital image of a page in a bound publication, for example, a book, a journal and other bound publications, may be challenging due to the inability to lay the publication flat, because of the publication binding, during image acquisition. Content near the binding may become distorted due to the physical distortion of the page during image acquisition, making reading of the content difficult and making subsequent document processing, for example, optical character recognition (OCR) and other processes in a document-processing workflow, less reliable. Methods and systems for correcting for this distortion may be desirable.

SUMMARY

Some embodiments of the present invention comprise methods and systems for fitting a mesh to an image of a document page.

Some embodiments of the present invention comprise methods and systems for fitting a mesh to an image of a document page and correcting a distortion in the image of the document page using the mesh.

According to a first aspect of the present invention, a rectangular-form mesh may be overlaid on a displayed document image.

According to a second aspect of the present invention, corner points in the rectangular-form mesh may be moved to coincide with corner points of a document page in the displayed document image, and a corner-aligned mesh may be overlaid on the displayed document image.

According to a third aspect of the present invention, a cubic Bezier curve may be fit to the top edge of the document page, a cubic Bezier curve may be fit to the bottom edge of the document page and an edge-aligned mesh may be overlaid on the displayed image.

According to a fourth aspect of the present invention, an inverse projective transformation may be applied to the patches of the mesh to correct the distortion in the image of the document page.

The foregoing and other objectives, features, and advantages of the invention will be more readily understood upon consideration of the following detailed description of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL DRAWINGS

FIG. **1** is a picture illustrating an exemplary document image comprising facing pages of a bound document;

FIG. **2** is a picture illustrating an exemplary Bezier curve;

FIG. **3** is a chart describing exemplary embodiments of the present invention comprising fitting a mesh to an image of a document page, wherein said mesh comprises a top edge comprising a first Bezier curve and a bottom edge comprising a second Bezier curve;

FIG. **4** is a picture illustrating an exemplary rectangular-form mesh according to exemplary embodiments of the present invention;

FIG. **5** is a picture illustrating an exemplary corner-aligned mesh according to exemplary embodiments of the present invention;

FIG. **6** is a picture illustrating an exemplary edge-aligned mesh according exemplary embodiments of the present invention; and

FIG. **7** is a chart describing exemplary embodiments of the present invention comprising fitting a mesh to an image of a document page, wherein said mesh comprises a top edge comprising a first Bezier curve and a bottom edge comprising a second Bezier curve, and correcting a perspective distortion in said image using said mesh.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Embodiments of the present invention will be best understood by reference to the drawings, wherein like parts are designated by like numerals throughout. The figures listed above are expressly incorporated as part of this detailed description.

It will be readily understood that the components of the present invention, as generally described and illustrated in the figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of the methods, systems and apparatus of the present invention is not intended to limit the scope of the invention, but it is merely representative of the presently preferred embodiments of the invention.

Elements of embodiments of the present invention may be embodied in hardware, firmware and/or a non-transitory computer program product comprising a computer-readable storage medium having instructions stored thereon/in which may be used to program a computing system. While exemplary embodiments revealed herein may only describe one of these forms, it is to be understood that one skilled in the art would be able to effectuate these elements in any of these forms while resting within the scope of the present invention.

Although the charts and diagrams in the figures may show a specific order of execution, it is understood that the order of execution may differ from that which is depicted. For example, the order of execution of the blocks may be changed relative to the shown order. Also, as a further example, two or more blocks shown in succession in a figure may be executed concurrently, or with partial concurrence. It is understood by those with ordinary skill in the art that a non-transitory computer program product comprising a computer-readable storage medium having instructions stored thereon/in which may be used to program a computing system, hardware and/or firmware may be created by one of ordinary skill in the art to carry out the various logical functions described herein.

Capturing a non-distorted digital image of a page in a bound publication, for example, a book, a journal and other bound publications, may be challenging due to the inability to lay the publication flat, because of the publication binding, during image acquisition. Content near the binding may become distorted due to the physical distortion of the page during image acquisition, making reading of the content difficult and making subsequent document processing, for example, optical character recognition (OCR) and other pro-

cesses in a document-processing workflow, less reliable. Methods and systems for correcting for this distortion may be desirable.

Some embodiments of the present invention may be understood in relation to FIG. **1** which illustrates an exemplary document image **100** of facing pages in a bound publication. One **102** of the facing pages, in this exemplary image **100**, is imaged in its entirety. While the other **104** of the facing pages, in this exemplary image **100**, is partially imaged. A region **106** whereat the two pages **102**, **104** meet may correspond to the binding of the publication. Due to the physical distortion of the bound publication during image acquisition, the boundaries **108**, **110**, **112**, **114**, **116**, **118**, **120** of the pages **102**, **104** in the image **100** may not form rectangular regions. The distorted pages **102**, **104** may be referred to as curled pages. Because the curled pages **102**, **104** are developable surfaces, each page **102**, **104** may be modeled, according to embodiments of the present invention, by a mesh comprised of cubic Bezier curves, also referred to as Bezier curves, running in the direction of the curl and connected by straight lines running in the normal direction.

In some embodiments of the present invention, a top edge **108** and a bottom edge **112** of a document page **102** in a document image **100** may be modeled with a first cubic Bezier curve and a second cubic Bezier curve, respectively. A cubic Bezier curve may be understood in relation to FIG. **2**. FIG. **2** depicts an exemplary cubic Bezier curve **200**. A cubic Bezier curve is a parametric curve whose shape is defined by four control points, P_0, P_1, P_2, P_3, according to the equation:

$$B(t)=(1-t)^3P_0+3(1-t)^2tP_1+3(1-t)t^2P_2+t^3P_3,\ t\in[0,1],$$

where t is the parameter of the parametric curve and P_0, P_1, P_2 and P_3 are planar points. The parametric curve, B(t), is bounded by the convex hull of the control points departing from P_0, where t=0, following tangent direction P_0P_1, and arriving at P_3, where t=1, following tangent direction P_2P_3. P_1 and P_2 may be referred to as intermediate control points. In the exemplary Bezier curve **200** shown in FIG. **2**, the four planar points P_0 **202**, P_1 **204**, P_2 **206** and P_3 **208** are shown in addition to the tangent lines P_0P_1 **210** and P_3P_2 **212**.

Some embodiments of the present invention comprising a mesh-fitting method(s) **300** for fitting a mesh to an imaged document page may be understood in relation to FIGS. **3-6**. Initially, referring to FIGS. **3** and **4**, a rectangular-form mesh **400** may be overlaid **302** on a document image **402** displayed on the display of a touch-enabled device, for example, a computer, a tablet device, a mobile device and other touch-enabled devices. The rectangular-form mesh **400** may comprise four vertices: a top-left vertex **404**, a top-right vertex **406**, a bottom-right vertex **408** and a bottom-left vertex **410**, a top edge **412** and a bottom edge **414**. The top edge **412** may be connected to the bottom edge **414** by a left edge **416** between the top-left vertex **404** and bottom-left vertex **410**. The top edge **412** may be connected to the bottom edge **414** by a right edge **418** between the top-right vertex **406** and bottom-right vertex **408**. A plurality of lines (four shown **420**, **422**, **424**, **426**) may connect equal-spaced points **428**, **430**, **432**, **434** along the top edge **412** with corresponding equal-spaced points **436**, **438**, **440**, **442** along the bottom edge **414**. Patches, for example, two labeled **454**, **456**, within the rectangular-form mesh **400**, may be formed by connecting equal-spaced points along adjacent vertical lines in the rectangular-form mesh **400**. In some embodiments of the present invention, each of six vertical lines within the rectangular-form mesh **400** may be divided into ten segments, thereby generating fifty patches.

A user may move, also considered drag, via touch, mouse, digital-pen device or other interface device, the corners **404**, **406**, **408**, **410** of the rectangular-form mesh **400** to coincide with the corners **444**, **446**, **448**, **450** of a document page **452** in the document image **402**, and the coincident corner points may be received **304** in the mesh-fitting method **300**.

Referring to FIG. **5**, a corner-aligned mesh **500** may be overlaid, also considered superimposed, **306** on the document image **502**. The corner-aligned mesh **500** may comprise four vertices: a top-left vertex **504** corresponding to the top-left corner **444** of the document page **452**, a top-right vertex **506** corresponding to the top-right corner **446** of the document page **452**, a bottom-right vertex **508** corresponding to the bottom-right corner **448** of the document page **452** and a bottom-left vertex **510** corresponding to the bottom-left corner **450** of the document page **452**, a top edge **512** and a bottom edge **514**. The top edge **512** may be connected to the bottom edge **514** by a left edge **516** between the top-left vertex **504** and bottom-left vertex **510**. The top edge **512** may be connected to the bottom edge **514** by a right edge **518** between the top-right vertex **506** and bottom-right vertex **508**. A plurality of lines (four shown **520**, **522**, **524**, **526**) may connect equal-spaced points **528**, **430**, **532**, **534** along the top edge **512** with corresponding equal-spaced points **536**, **538**, **540**, **542** along the bottom edge **514**. Patches, for example, two labeled **544**, **546**, within the corner-aligned mesh **500**, may be formed by connecting equal-spaced points along adjacent vertical lines in the corner-aligned mesh **500**. In some embodiments of the present invention, each of six vertical lines within the corner-aligned mesh **500** may be divided into ten segments, thereby generating fifty patches. The displayed rectangular-form mesh may be removed from the display when the corner-aligned mesh is overlaid.

Intermediate control points may be determined **308** for a first cubic Bezier curve corresponding to the top edge **512** and for a second cubic Bezier curve corresponding to the bottom edge **514**.

In some embodiments of the present invention, a dragging action of a corner point may effectuate a continuously re-drawn mesh in response to the dragging action. In these embodiments, an intermediate corner-aligned mesh, corresponding to a corner movement, may be generated and displayed.

A touch displacement may be received **310** in the mesh-fitting method **300**. The touch displacement may be effectuated by a finger touch, a mouse action, a digital-pen device or other interface method. A touch displacement may correspond to a user touch gesture commencing at an initial touch point and terminating at a final touch point. A nearest intermediate control point to the initial touch point may be determined **312**, and the mesh edge, top edge or bottom edge, associated with the nearest intermediate control point may be adjusted **314** accordingly by moving the nearest intermediate control point a displacement commensurate with the received touch displacement. For example, a received touch displacement of a first length in a first direction may be applied to the nearest intermediate control point.

Referring to FIG. **6**, an edge-aligned mesh **600** may be overlaid **316** on the document image **602**. The edge-aligned mesh **600** may comprise four vertices: a top-left vertex **604** corresponding to the top-left corner **444** of the document page **452**, a top-right vertex **606** corresponding to the top-right corner **446** of the document page **452**, a bottom-right vertex **608** corresponding to the bottom-right corner **448** of the document page **452** and a bottom-left vertex **610** corresponding to the bottom-left corner **450** of the document page **452**, a top, cubic Bezier curve edge **612** and a bottom cubic Bezier

curve edge **614**. The top edge **612** may be connected to the bottom edge **614** by a left edge **616** between the top-left vertex **604** and bottom-left vertex **610**. The top edge **612** may be connected to the bottom edge **614** by a right edge **618** between the top-right vertex **606** and bottom-right vertex **608**. A plurality of lines (four shown **620**, **622**, **624**, **626**) may connect equal-t-parameter-spaced points **628**, **630**, **632**, **634** along the top edge **612** with corresponding equal-t-parameter spaced points **636**, **638**, **640**, **642** along the bottom edge **614**. In some embodiments of the present invention t-parameter values of 0.2, 0.4, 0.6 and 0.8 correspond to the four lines **620**, **622**, **624**, **626**, respectively. Patches, for example, two labeled **644**, **646**, within the edge-aligned mesh **600**, may be formed by connecting equal-spaced points along adjacent vertical lines in the edge-aligned mesh **600**. In some embodiments of the present invention, each of six vertical lines within the edge-aligned mesh **600** may be divided into ten segments, thereby generating fifty patches. The displayed corner-aligned mesh may be removed from the display when the edge-aligned mesh is overlaid.

In some embodiments of the present invention, a dragging action associated with a touch displacement may effectuate a continuously re-drawn mesh in response to the dragging action. In these embodiments, an intermediate edge-aligned mesh, corresponding to a touch displacement movement, may be generated and displayed.

The mesh-fitting method **300** may continue **318** receiving touch displacements **310** and displaying an updated edge-adjusted mesh.

Some embodiments of the present invention may be described in relation to FIG. **7**. FIG. **7** is a chart describing method(s) **700** for correcting distortion in an image of a page in a bound publication.

A document image may be displayed **702** on the display of a touch-enabled device, for example, a computer, a tablet device, a mobile device and other touch-enabled devices.

A rectangular-form mesh may be overlaid **704** on the document image displayed on the touch-enabled-device display. The rectangular-form mesh may comprise four vertices, also considered corners: a top-left vertex, a top-right vertex, a bottom-right vertex and a bottom-left vertex, a top edge and a bottom edge. The top edge may be connected to the bottom edge by a left edge between the top-left vertex and bottom-left vertex. The top edge may be connected to the bottom edge by a right edge between the top-right vertex and bottom-right vertex. A plurality of lines may connect equal-spaced points along the top edge with corresponding equal-spaced points along the bottom edge. In some embodiments of the present invention, four lines, in addition to the left edge and the right edge, may connect the equal-spaced points along the top edge with the corresponding equal-spaced points along the bottom edge. Patches, within the rectangular-form mesh, may be formed by connecting equal-spaced points along adjacent vertical lines in the rectangular-form mesh. In some embodiments of the present invention, each of six vertical lines within the rectangular-form mesh may be divided into ten segments, thereby generating fifty patches.

A touch gesture may be received **706**. In some embodiments of the present invention, the touch gesture may be received in a gesture processor resident in the touch-enabled device.

The received touch gesture may be examined **708** to determine if the received touch gesture is a drag gesture associated with a corner of the rectangular-form mesh. The drag gesture may be associated with an initial gesture point at which the drag gesture commences and a final gesture point at which the drag gesture terminates. In some embodiments, a drag gesture may be associated with a corner of the rectangular-form mesh if the drag gesture is initiated with a region proximal to a corner of the rectangular-form mesh.

If the received touch gesture is determined to be a drag gesture associated with a corner of the rectangular-form mesh **710**, then a corner-aligned mesh may be generated **712**. The corner-aligned mesh may be an adjusted form of the rectangular-form mesh, wherein the adjusted form of the rectangular-form mesh replaces the corner of the rectangular-form mesh proximal to the initial gesture point with the final gesture point and appropriately adjusts the corresponding edge, the left edge, the right edge and the plurality of lines connecting equal-spaced points between the adjusted corresponding edge and the other, original edge.

The corner-aligned mesh may be overlaid **714** on the document image. The previously overlaid mesh may be removed when the most recently generated mesh is overlaid.

The method **700** may wait **716** to receive additional touch gestures.

If the received touch gesture is determined not to be a drag gesture associated with a corner of the rectangular-form mesh **718**, then the touch gesture may be examined **720** to determine if it is a touch gesture indicative that all of the vertices in the currently overlaid mesh are associated with document page corners. In some embodiments, a touch gesture indicative that all of the vertices in the current mesh are associated with document page corners may comprise a double-tap touch gesture. In alternative embodiments, a touch gesture indicative that all of the vertices in the current mesh are associated with document page corners may comprise a touch gesture associated with a menu item corresponding to completion of corner selection.

If corner selection is not complete **722**, then the method **700** may wait **722** to receive **706** additional touch gestures in a grid-corner-drag loop.

If corner selection is complete **724**, then the method **700** may wait to receive a touch gesture **726** in an mesh-fit-complete loop. When a touch gesture is received **726**, then the touch gesture may be examined **728** to determine if the mesh-fit process is complete. In some embodiments, a touch gesture indicative that the mesh-fit process is complete may comprise a double-tap touch gesture. In alternative embodiments, a touch gesture indicative that the mesh-fit process is complete may comprise a touch gesture associated with a menu item corresponding to completion of mesh fitting.

If the received touch gesture is determined to indicate that the mesh-fit process is complete **730**, then the image region within the final fitted mesh may be transformed to correct for the projective distortion in the image. In some embodiments of the present invention, an inverse projective transformation may be applied in a strip-by-strip fashion along a ruled direction within the finally determined mesh. In alternative embodiments of the present invention, an inverse projective transformation may be applied in a patch-by-patch fashion within the finally determined mesh.

In some embodiments of the present invention, a patch within the finally determined mesh whereat the surface curvature is high may be subdivided to create smaller patches.

The flattened document page may be displayed **734**.

If the received touch gesture is determined to indicate that the mesh-fit process is not complete **736**, then the nearest intermediate control point may be determined **738**, and the touch gesture may be interpreted as a touch displacement corresponding to a user touch gesture commencing at an initial touch point and terminating at a final touch point. The edge curve, top edge or bottom edge, associated with the nearest intermediate control point may be adjusted **740**

accordingly by moving the nearest intermediate control point a displacement commensurate with the received touch displacement. For example, a received touch displacement of a first length in a first direction may be applied to the nearest intermediate control point.

An edge-aligned mesh may be overlaid **742** on the document image. The edge-aligned mesh may comprise four vertices: a top-left vertex corresponding to the top-left corner of the document page, a top-right vertex corresponding to the top-right corner of the document page, a bottom-right vertex corresponding to the bottom-right corner of the document page and a bottom-left vertex corresponding to the bottom-left corner of the document page, a top, cubic Bezier curve edge and a bottom cubic Bezier curve edge. The top edge may be connected to the bottom edge by a left edge between the top-left vertex and bottom-left vertex. The top edge may be connected to the bottom edge by a right edge between the top-right vertex and bottom-right vertex. A plurality of lines may connect equal-t-parameter-spaced points along the top edge **612** with corresponding equal-t-parameter spaced points along the bottom edge. In some embodiments of the present invention t-parameter values of 0.2, 0.4, 0.6 and 0.8 correspond to four lines, respectively. Patches, within the edge-aligned mesh, may be formed by connecting equal-spaced points along adjacent vertical lines in the edge-aligned mesh. In some embodiments of the present invention, each of six vertical lines within the edge-aligned mesh may be divided into ten segments, thereby generating fifty patches. A previously displayed mesh may be removed from the display when the currently generated mesh is overlaid.

In some embodiments of the present invention, a dragging action associated with a touch displacement may effectuate a continuously re-drawn mesh in response to the dragging action. In these embodiments, an intermediate edge-aligned mesh, corresponding to a touch displacement movement, may be generated and displayed.

The mesh-fitting method may continue receiving touch displacements and displaying an updated edge-adjusted mesh.

The method **700** may wait **744** to receive **726** additional touch gestures in a mesh-fit-complete loop.

Some embodiments of the present invention may comprise a computer program product comprising a computer-readable storage medium having instructions stored thereon/in which may be used to program a computing system to perform any of the features and methods described herein. Exemplary computer-readable storage media may include, but are not limited to, flash memory devices, disk storage media, for example, floppy disks, optical disks, magneto-optical disks, Digital Versatile Discs (DVDs), Compact Discs (CDs), micro-drives and other disk storage media, Read-Only Memory (ROMs), Programmable Read-Only Memory (PROMs), Erasable Programmable Read-Only Memory (EPROMS), Electrically Erasable Programmable Read-Only Memory (EEPROMs), Random-Access Memory (RAMS), Video Random-Access Memory (VRAMs), Dynamic Random-Access Memory (DRAMs) and any type of media or device suitable for storing instructions and/or data.

The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding equivalence of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

What is claimed is:

1. A method for generating a corrected document image of an image of a document page, said method comprising:
- displaying a document image on a touch-enabled-device display;
- overlaying a rectangular-form mesh on said displayed document image;
- receiving a plurality of corner points;
- overlaying a corner-aligned mesh on said displayed document image;
- receiving a touch displacement comprising an initial touch point and a final touch point;
- determining a nearest intermediate control point, wherein said nearest intermediate control point is an intermediate control point of an associated cubic Bezier curve, to said initial touch point;
- adjusting an edge curve associated with said nearest intermediate control point based on said touch displacement;
- generating an edge-aligned mesh based on said adjusted edge curve;
- correcting a portion of said image of said document page corresponding to said edge-aligned mesh; and
- generating a corrected document image, wherein said corrected document image comprises said corrected portion.

2. A method as described in claim **1**, wherein said corner-aligned mesh comprises a top edge and a bottom edge, wherein said top edge is a first cubic Bezier curve and said bottom edge is a second cubic Bezier curve.

3. A method as described in claim **2**, wherein said edge curve is associated with one of said top edge and said bottom edge.

4. A method as described in claim **1**, wherein receiving a first corner point in said plurality of corner points comprises:
- receiving a touch gesture in a gesture processor; and
- determining if said touch gesture is a drag gesture associated with a corner of said rectangular-form mesh.

5. A method as described in claim **4**, wherein said determining if said touch gesture is a drag gesture associated with a corner of said rectangular-form mesh comprises comparing an initial point associated with said touch gesture with a location of a vertex of said rectangular-form mesh.

6. A method as described in claim **4**, wherein said first corner point is associated with a final point associated with said drag gesture.

7. A method as described in claim **1**, wherein said adjusting an edge curve associated with said nearest intermediate control point comprises:
- determining a touch-displacement distance;
- determining a touch-displacement direction; and
- adjusting a cubic Bezier curve associated with said edge curve by moving said nearest intermediate control point a distance corresponding to said touch-displacement distance in a direction corresponding to said touch-displacement direction.

8. A method as described in claim **1**, wherein said correcting comprises an inverse projective transformation.

9. A method as described in claim **8**, wherein said inverse projective transformation is applied in a fashion selected from the group consisting of a strip-by-strip fashion along a ruled direction in said edge-aligned mesh and a patch -by-patch fashion within said edge-aligned mesh.

10. A method as described in claim **9**, further comprising subdividing any patch in said edge-aligned mesh wherein a surface curvature associated with said any patch exceeds a first threshold.

11. A method as described in claim 1 further comprising overlaying an intermediate corner-aligned mesh on said displayed document image in response to receiving each of said corner points in said plurality of corner points.

12. A method for correcting an image of a document page, said method comprising:

displaying a document image on a touch-enabled-device display;

overlaying a rectangular-form mesh on said displayed document image;

receiving a plurality of corner points;

overlaying a corner-aligned mesh on said displayed document image;

receiving a touch displacement comprising an initial touch point and a final touch point;

determining a nearest intermediate control point, wherein said nearest intermediate control point is an intermediate control point of an associated cubic Bezier curve, to said initial touch point;

adjusting an edge curve associated with said nearest intermediate control point based on said touch displacement;

generating an edge-aligned mesh based on said adjusted edge curve; and

correcting a portion of said document image corresponding to said edge-aligned mesh.

13. A method as described in claim 12, wherein said corner-aligned mesh comprises a top edge and a bottom edge, wherein said top edge is a first cubic Bezier curve and said bottom edge is a second cubic Bezier curve.

14. A method as described in claim 13, wherein said edge curve is associated with one of said top edge and said bottom edge.

15. A method as described in claim 12, wherein receiving a first corner point in said plurality of corner points comprises:

receiving a touch gesture in a gesture processor; and

determining if said touch gesture is a drag gesture associated with a corner of said rectangular-form mesh.

16. A method as described in claim 15, wherein said determining if said touch gesture is a drag gesture associated with a corner of said rectangular-form mesh comprises comparing an initial point associated with said touch gesture with a location of a vertex of said rectangular-form mesh.

17. A method as described in claim 15, wherein said first corner point is associated with a final point associated with said drag gesture.

18. A method as described in claim 12, wherein said adjusting an edge curve associated with said nearest intermediate control point comprises:

determining a touch-displacement distance;

determining a touch-displacement direction; and

adjusting a cubic Bezier curve associated with said edge curve by moving said nearest intermediate control point a distance corresponding to said touch-displacement distance in a direction corresponding to said touch-displacement direction.

19. A method as described in claim 12, further comprising subdividing any patch in said edge-aligned mesh wherein a surface curvature associated with said any patch exceeds a first threshold.

20. A method as described in claim 12 further comprising overlaying an intermediate corner-aligned mesh on said displayed document image in response to receiving each of said corner points in said plurality of corner points.

* * * * *